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## EXTENDED COGNITION, ASSISTIVE TECHNOLOGY AND EDUCATION

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**ABSTRACT.** Assistive technology (AT) is widely used in contemporary special needs education. Our interest is in the extent to which we can conceive of certain uses of AT in this educational context as a form of extended cognition. It is argued that what is critical to answering this question is that the relationship between the student and the AT is more than just that of subject-and-instrument, but instead incorporates a fluidity and spontaneity that puts it on a functional par with their use of the student's biological cognitive traits. It is claimed that AT use in special needs education offers an especially plausible case of extended cognition for just this reason. It is further maintained that understanding AT in this fashion has some important philosophical and practical ramifications, including how we should conceive of mainstream education, given that this is increasingly conducted within highly technologically-embedded environments.

### 0. INTRODUCTORY REMARKS

*Assistive technology* (AT) is an umbrella term for devices that are employed to assist people with disabilities, people recuperating from operations, and/or the elderly. It can include something as low-tech and straightforward as a walking frame, and something as complex and high-tech as the

distinctive smart electric wheelchair employed by Stephen Hawking in the later part of his life. The terminology is used quite loosely in the literature, but often refers to such devices that are explicitly designed for this purpose, as opposed to technology that is simply being used in an assistive manner, and in what follows we will be understanding AT in this way.<sup>1</sup> We think it is also important at this early stage, however, that we also make a distinction between AT and *AT systems*, where the term ‘systems’ refer to “the development and application of organized knowledge, skills, procedures, and policies relevant to the provision, use, and assessment of assistive products [*or technology*].” (Khasnabis, Mirza & MacLachlan 2015, 2229)

Our particular concern in this paper is the kind of AT that is widely used in the special needs education of children and young adults. As we will see, this is especially interesting because of its employment within AT systems in an educational context, where learners are learning how to use AT to support their developmental needs. As such, this context can give us particular insight into how a person transitions from being a mere AT user, where the AT could be considered just an instrument, to someone for whom AT is integrated into his or her extended cognitive processes and corresponds to his or her development of cognitive agency. We will call this latter scenario *extended cognitive integration* (ECI). Moreover, we argue that *how* a person with disabilities learns to use AT is critical for determining whether it is a case of ECI. Drawing on international theoretical and empirical research on human learning, we will hypothesize that learning processes wherein the learner ‘productively struggles’ to adapt the AT to their needs are essential for supporting the learner’s transition from mere AT use to ECI.

In the first section, we consider extended cognition and AT more generally, and then focus on specific forms of AT which can plausibly be thought to constitute a particularly clear-cut form of extended cognition. In the second section, we differentiate between mere AT use and ECI. In section three, we discuss empirical data from our pilot study on AT and special needs education that provides support for the claim that AT use can be profitably understood as extended cognition. In section four, we explore the implications of this thesis, including its relevance to our thinking about education more generally. Finally, in section five, we offer some concluding remarks.

## 1. EXTENDED COGNITION AND AT

While there is a wealth of theoretical literature on AT, very little of it is from a philosophical perspective.<sup>2</sup> This is especially surprising once one reflects how this technology seems centrally relevant to a number of live philosophical debates, such as concerning the nature of cognitive processes. In particular, there is a thriving research program devoted to extended and embodied cognitive processes, a program that is rooted in philosophy but now extends to the cognitive sciences more generally. The usual source for this program is a short paper making the case for the ‘extended mind’ by Andy Clark and David Chalmers (1998). This paper famously argues, in sloganizing form at least, that the mind is not contained exclusively within the brain, but rather extends into the external world. Expressed a bit more carefully, their contention is that in certain cases we should think of a subject’s mental states, such as her beliefs, as being ‘extended’ beyond the brain and central nervous system of the subject to take in relevant parts of her external environment that she is interacting with.<sup>3</sup>

Our interest in this paper is not on this extended mind thesis as such, but rather a more specific thesis in the vicinity of this claim that is specifically concerned with extended cognition. In particular, can there be cognitive processes that extend beyond the skin and skull of the subject to take in elements of the subject’s external environment as proper parts? Note that it is not obvious that the extended mind hypothesis entails, or is entailed by, the extended cognition hypothesis. If one thinks that the cognitive is the ‘mark of the mental’, then one might thereby generate a tight conceptual connection between these two theses, but this is far from being an uncontroversial claim to make. Indeed, one could argue that these two claims can come apart in both directions. Perhaps there are extended mental states, but not in any way that essentially figure in cognitive processes? Or, more plausibly, perhaps there are no extended mental states, but nonetheless there are extended cognitive processes?<sup>4</sup> In any case, our concern will be with the more specific extended cognition thesis.<sup>5</sup> We will be contending that understanding certain kinds of AT through the lens of extended cognition is theoretically illuminating.<sup>6</sup>

It is especially surprising that debates about extended cognition have not engaged with the theoretical literature on AT, given that the famous example offered by Clark and Chalmers (1998) to illustrate their claim about the extended mind (though the case just as much illustrates a parallel point about extended cognition) concerns the use of what might, in a very broad sense at least, be described as AT. The example involves a subject, Otto, who has Alzheimer’s disease and hence is

losing his memory. As a result, he adopts a policy of carrying a notebook around with him where he collates useful information that he needs in his day-to-day life. The notebook thus constitutes, at least in a loose sense (in that it is not a technological solution that is explicitly designed for this purpose, which is how we are understanding AT), a kind of AT that is enabling Otto to cope with the cognitive impairment caused by the Alzheimer's disease.

Clark and Chalmers argue that the information in Otto's notebook can, in certain circumstances at least, qualify as a genuine part of Otto's memory, such that there is a real sense in which Otto has both (failing) biological memory and an additional non-biological memory in the form of the notebook. (They even go so far as to say that some of Otto's *beliefs* are contained in the notebook, though given our concern is extended cognition rather than the extended mind, then we can set this further claim about Otto's putatively extended mental states to one side for our purposes). If that's right, then Otto is employing an *extended cognitive process*, where this is a cognitive process that includes as a proper part a feature of Otto's external environment, in this case the notebook.

The rationale that Clark and Chalmers offer for this claim primarily concerns their 'parity principle' (which note is explicitly cast in terms of *cognitive* processes specifically):

"If, as we confront some task, a part of the world functions as a process which, were it done in the head, we would have no hesitation in recognising as part of the cognitive process, then that part of the world is (so we claim) part of the cognitive process." (Clark & Chalmers 1998, 8)

The idea is thus that where there is no functional difference between the role played by the external device and the corresponding internal cognitive process, then there is no principled basis to claim that the former is not itself a part of the subject's cognitive processes. With this point in mind, a great deal of the scrutiny of these cases tends to focus on whether there really is the functional parity in play that Clark and Chalmers allege.

With regard to this claim of functional parity, Clark (2010) offers the following set of criteria that are relevant in this regard (which in turn make explicit criteria that are less explicitly invoked in Clark & Chalmers (1998)):

- 1) "That the resource be reliably available and typically invoked."
  - 2) "That any information thus retrieved be more-or-less automatically endorsed. It should not usually be subject to critical scrutiny. [...] It should be deemed about as trustworthy as something retrieved clearly from biological memory."
  - 3) "That information contained in the resource should be easily accessible as and when required."
- (Clark 2010, 46)

Clark's focus in offering these 'glue and trust conditions', as they are widely known, is explicitly the memorial case (in line with the original Otto example), but the idea is that such conditions are meant to be generally applicable to cases of extended cognition. In any case, one can see how they might apply to the Otto example. The thought is that it is not just any use of a notebook that qualifies as extended cognition, but only usage that meets these conditions, where the conditions are in turn to be understood as being only as demanding as the corresponding biological cognitive process (in line with the parity principle). So the information in Otto's notebook needs to be as reliably available to Otto as his biological memories are (i.e., the notebook needs to be the kind of thing that is generally on his person); the information in this notebook is as automatically endorsed as his biological memories typically are (which allows, of course, for some critical scrutiny of them, as is sometimes appropriate with one's biological memories); and the information in the notebook should be as readily accessible as his biological memories are (which is compatible with them not always being immediately accessible, given that one's biological memories can sometimes be hard to recover).

In more recent work on extended cognition, commentators have in addition stressed the importance of the extended cognitive process being *cognitively integrated* with the subject's existing cognitive processes, where the cognitively integrated set of such cognitive processes is understood as the subject's *cognitive character*.<sup>7</sup> (It follows that if there is extended cognition, then a subject can have an *extended cognitive character*—i.e., one that includes both extended and non-extended cognitive processes). So, for example, it is important to Otto's use of the notebook that the information it delivers is part of wider feedback loops that interact with his other cognitive processes, just as one's normal memory does, where the glue and trust conditions are ways of ensuring that such feedback loops occur in functionally similar ways to normal memory. If one finds oneself remembering something that conflicts with the current evidence of one's senses, for example (e.g., one recalls that one previously parked one's car in the garage, but one now seems to see it out on the street), then that should trigger some reflection on which of these deliverances should be trusted. The same should also be true of the extended cognitive processes (e.g., where what Otto reads in the notebook appears to conflict with what he can presently see). Conversely, where these deliverances are in accord with one another—whether the cognitive processes are extended or nonextended—then one would expect each to seamlessly guide the other accordingly in a reciprocal flow of informational inputs, which in turn guide action and hence lead to further informational inputs, and so on. For example, remembering that one parked one's car in the garage—or, for that matter, seeing a note in

one's 'memorial notebook' to this effect—guides one's perceptual activities in terms of how one goes about fetching one's car, which in turn confirms one's memory and stimulates further memories (e.g., about where one needs to be driving).

This way of thinking about cognitive integration is meant to go hand-in-hand with the kind of functional equivalence outlined by Clark and Chalmers, and also accord with the glue and trust criteria. In particular, one common way of thinking about cognitive integration is in virtue-theoretic terms that are familiar from mainstream epistemology.<sup>8</sup> On this model, whether a reliable belief-forming process counts as one of one's cognitive processes, and thus the kind of cognitive process that can generate knowledge, depends on whether the cognitive success of such a process stands in an appropriate explanatory relation to one's cognitive character, and thus manifests one's cognitive agency. This will in turn depend on whether the cognitive process in question is sufficiently integrated with the other cognitive processes that make up one's cognitive character. For example, what sets apart one's perceptual faculties from other belief-forming processes (which may happen to be reliable), such as relying on one's hunches, is that cognitive success in the former case (but not the latter case, even when it happens to be reliable), due to how it is integrated within one's cognitive character, is naturally attributable to one's cognitive agency rather than to other factors, such as luck or external intervention.

Accordingly, what matters when it comes to extended cognitive processes is whether they are sufficiently integrated within the subject's cognitive character that we automatically attribute their cognitive success to the subject's cognitive agency as opposed to other factors. In that case, we are to think of the subject's cognitive character as itself extended (in that it involves the integration of both extended and non-extended cognitive processes). Moreover, the extended cognitive processes in play, in virtue of their integration within a wider cognitive character, can generate true beliefs that are in the market for knowledge (what is known as *extended knowledge*).<sup>9</sup>

Proponents of this line emphasise that it is importantly relevant here that the explanatory relation in question is relatively modest. In particular, there are independent reasons for not characterising this relation as demanding that the subject's cognitive success is primarily (i.e., overarchingly) attributable to her cognitive agency; what is required is only a significant degree of explanatory connection (i.e., that the cognitive success is more attributable to cognitive agency than to other factors).<sup>10</sup> This makes the virtue-theoretic account of cognitive integration particularly suitable to making sense of extended cognition, given that extended cognitive processes are at least

arguably much more dependent upon the satisfaction of environmental conditions than biological cognitive processes.<sup>11</sup>

Moreover, there is a second sense in which this model of cognitive integration is modest, in that it doesn't demand active or reflective engagement on the part of the subject, at least in normal conditions. Consider the perceptual case. When conditions are normal, the subject doesn't need to be doing anything specific in order to ensure that their perceptual cognitive processes are suitably cognitively integrated. Instead, reflection, and active engagement as a result of such reflection, is only called for when something abnormal occurs, such as when the deliverances of one's perceptual cognitive processes conflict with, for example, the deliverances of one's memorial cognitive processes.

Interestingly, the more detail one fills into one's conception of what is needed for extended cognition to occur, the less plausible the Otto case becomes, even despite its supposedly canonical status. We will explore why in more detail below, but for now just consider whether one would naturally ascribe Otto's cognitive success when employing the notebook to his cognitive agency rather than to a factor that is external to his cognitive agency? We think our inclinations are clearly in the latter camp, and that this reflects the fact that Otto's relationship to his notebook is likely to be straightforwardly one of subject-to-instrument (mere AT user), rather than a genuine case of extended cognition (ECI). (Our reasons for this claim will become apparent shortly). In any case, our concern is not with the specifics of the Otto example, but rather the more important general question of whether there can be *bona fide* cases of extended cognition, and whether the use of AT fully integrated within an AT system fits the bill in this regard. We will be arguing for a positive answer in both cases.

Before we get to these claims, we want to make a clarificatory point which will help structure our discussion. We want to restrict our attention to extended cognitive processes which involve information-processing that takes place outwith the brain and central nervous system of the agent. This restriction is important because there is a broad sense of extended cognition that allows any external factor, even if it is not involved in information-processing, to be a proper part of an extended cognitive process. So, for example, it has been noted by cognitive scientists that having free use of one's hands can significantly enhance one's cognitive skills in certain domains, such as solving geometrical problems. One might thus regard one's movements with one's hands in such cases as a proper part of the cognitive process in play.<sup>12</sup> But this wouldn't be an example of a cognitive process in the sense that we have in mind, as there is no external information-processing



taking place.<sup>13</sup> The Otto case, in contrast, even though it might not be compelling as an example of extended cognition, does at least meet this requirement, given that the notebook is explicitly being used as an information storage device.

This restriction to information-processing technology is important for a number of reasons, but our principal motivation for introducing it is to ensure that we delineate a robust kind of extended cognition, one that is not merely enabled by environmental factors, but where environmental factors are actively part of the cognising that is taking place. It is, after all, undeniable that external factors can play an enabling role in cognition—for example, one’s eyesight is dependent on all manner of environmental conditions, such as good light and so forth, one’s deductive powers can be dependent on such environmental factors as whether there are distractions (e.g., ambient noise), and so on. Accordingly, where the environmental factors are not involved in information-processing, there will be a natural tendency to contend that what we are witnessing is not actually extended cognition but rather something else that is less philosophically iconoclastic, such as a kind of externally ‘scaffolded’ cognition.

This restriction will inevitably limit the kinds of AT that we will be considering. Rather than being artificial limbs or external supports, our interest is rather in those devices which interact with one’s cognitive processes more directly by supporting the information-processing in play, such as technology that enables communication or enhances memory, and so on.<sup>14</sup> In addition, recall our point from earlier that our focus will be AT as it is employed in special needs education for children and young adults. In particular, we are interested in how learners transition from mere AT use to ECI in educational settings. Our aim is to understand how learners can be supported by teachers to come to use this technology in such a way that it can be considered part of extended cognition. As we will see, along with the restriction to extended cognition that involves external information-processing, this enables us to bring the relevance of thinking of AT and AT systems along extended cognition lines into sharper relief.

## 2. MERE AT USE AND ECI

While there has been little in the way of serious theoretical discussion of the role of AT and its relationship to extended cognition, there has been considerable theoretical discussion devoted to the nature and application of AT. Interestingly, this discussion bears on the question of whether such

AT use could qualify as extended cognition (ECI). In particular, a number of these studies emphasise the importance of designing AT to ensure that it is fluently and seamlessly employed by the learner, such that it is incorporated into their daily routines in an unobtrusive fashion and utilised in unreflective ways by the subject.<sup>15</sup> In contrast, it is noted that the adoption of AT faces obstacles precisely because of perceptions (on both the potential user and those engaging with them, such as the educator) that it will not be easy to use (even once mastered), and that it therefore will not meet the individual needs of the subject.<sup>16</sup> These are barriers to AT adoption that are in addition to the usual issues affecting its use, such as cost, procurement, training, and so on.<sup>17</sup> The challenge to those designing AT has thus been to ensure that it can be seamlessly, and effectively, incorporated into the subject's life (while also affordable, straightforward to acquire, easy to implement, and so forth).<sup>18</sup>

This focus on fluency, ease of use, and unobtrusive integration into day-to-day life should remind us of the importance of cognitive integration to extended cognitive processes. Recall that the virtue-theoretic fleshing-out of the broadly functionalist account of extended cognition was in terms of whether the putative extended cognitive process was sufficiently integrated within the subject's cognitive character such that any cognitive success that resulted from this process would be naturally attributable to the subject's cognitive agency. Clearly, however, the extent to which the technology is fluently and seamlessly employed is going to have a large bearing on whether we would regard any cognitive process involving this technology as extended. In particular, what we will be sensitive to is whether the putatively extended cognitive process involves an employment of an external cognitive resource in a way that is as fluent and seamless as one's employment of a corresponding internal cognitive resource.

We noted earlier that while filling-out the detail of what is required for an cognitive process to count as extended in this virtue-theoretic way made extended cognition (and thus extended knowledge) more plausible, it also at the same time didn't sit well with supposedly canonical cases of extended cognition like Otto. We are now in a position to revisit this claim. The problem with the Otto case is that it isn't all that plausible that Otto's use of the notebook is as fluent and seamless as his employment of his biological memory. On the contrary, even if he readily employs the notebook, uncritically accepts its deliverances, and has reliable access to it—in line with the 'glue and trust' conditions noted above—his relationship to the notebook seems very different to his relationship to his biological memory. In particular, the former relationship is one of subject and-instrument, in contrast to the latter, which is not experienced in anything like this manner.

What we are looking for in plausible cases of extended cognition are thus scenarios where the use of the external cognitive resource really is so cognitively integrated that it is as seamlessly and fluently employed as the corresponding non-extended cognitive process. In that case, the relationship between the person and the external resource will no longer be one of subject-and-instrument, but rather akin to the non-instrumental relationship we paradigmatically have to our non-extended cognitive processes. This is where AT becomes very relevant, particularly in a developmental and educational setting. For what precisely seems to be aimed for here is the use of technology that satisfies this rubric. Yet the aim of seamless integration does not tell us about the process of how a learner moves from mere AT use to ECI.

Thus far, we have argued that extended cognitive processes are possible, and that cognitive integration is a central criterion of whether AT can be considered an extended cognitive process (and thus count as ECI). We have also noted that if AT is considered seamlessly integrated, then at some point in time prior to that it was not integrated by the user. A central question still remains, which is what does the process look like by which a person moves from mere AT use to employing AT as a seamlessly integrated extended cognitive process? Put another way, the question is how does the AT become, over time, so seamlessly and fluently employed by the learners concerned that it would satisfy the rubric for extended cognition? Note that the developmental and educational setting is particularly important here. The children and young people are being explicitly supported to learn to incorporate the AT into their cognitive practices in such a way that it becomes a functional part of their everyday life and enhances their overall wellbeing, which provides the foundation for transforming mere AT use into ECI. We argue that a particular understanding of learning as involving ‘productive struggle’ contributes to the cognitive integration of AT as part of an extended cognitive process. In our focus on learning via ‘productive struggle’, we are aligned with international research on human learning that considers productive struggle essential for students to learn with deep understanding in a way that supports their development of cognitive agency. In this context, a learner’s productive struggle is distinguished from ‘unproductive struggle’, indicating the learner is underchallenged, and from ‘destructive struggle’, indicating the learner is discouraged and shut down from the learning process.<sup>19</sup> This focus on the process of learning matters because if we understand how a learner can successfully move from employing AT in a non-integrated way (as a mere AT user) to employing AT as an extended cognitive process (ECI), then this has consequences not only for the design of AT, but also for the teaching of how to integrate AT.

### 3. UNDERSTANDING AT AS EXTENDED COGNITION: INTERVIEWS WITH TEACHERS AT A SCHOOL FOR LEARNERS WITH VISION IMPAIRMENT

Since there has been no sustained discussion of AT in the context of extended cognition, the foregoing discussion inevitably has a rather speculative flavour, in that one is having to extrapolate salient details about how AT is used in special needs education from studies which describe the use of AT in these settings that do not have this particular theoretical ramification in mind. In order to explore this issue more effectively, in a recent pilot study we engaged with the teaching staff at a school based in the United Kingdom that specializes in the education of children with vision impairments.

The learners at this school have varying degrees of vision impairment, and in many cases this is combined with other cognitive and physical impairments. Most learners at the school employ some form of AT, with many employing more than one form of AT. The kinds of AT used range from such devices as: ‘ultracanes’, which are canes fitted with ultrasound sensors that use an earpiece to relay information; several types of braille-based technology; and various kinds of voice-recognition and voice-activated software. As part of the study, in May 2018 we conducted an in-depth semi-structured focal group interview with five teachers (3 female, 2 male) in the school, who because of their long-term experience and knowledge working with learners with visual impairment offered specialist perspectives on learners’ experiences using AT. Our teacher participants included: a deputy head teacher; a specialist in assistive technology for visually impaired learners; a qualified teacher of learners with vision impairment (QTVI); a qualified mobility and habitation specialist; and a subject teacher at the school. One of the teachers was also visually impaired and was able to speak about the learners’ experiences by drawing on his own experience as an AT user. The interview was recorded, transcribed and anonymised. Our theoretical framework was informed by the above discussion on the connections between extended cognition, an AT systems approach focusing on user wellbeing, and the process of learning to use the AT. In particular, our questions focused on understanding what types of struggle learners engage in when learning to use a particular AT to meet their disability needs, and whether there is a connection between the type of struggle a learner engages in when learning to use a particular AT and the degree to which their resulting AT use can be considered part of their extended cognitive process.

Here, we provide a vignette, in which the teachers' describe a young boy, who we call Max, who was blind with a degree of hearing loss:

*Vignette*

***[Max] was very locked into his own world [...] this piece of technology helped him break out of his world.***

Max was forced to learn to use a new braille technology for reading, writing and communicating to replace his existing AT (Braille Apex) which was becoming redundant, in that the company who makes it would no longer support it and so the school was acquiring new devices. While the teachers described a few different learners' experiences, we have chosen this particular case of Max, because it illustrates the different types of struggle learners can engage in when learning to use a new AT, and suggests a connection between productive struggle, wellbeing and extended cognition. For these reasons, we consider this case particularly revealing.

All the teachers in the interview knew Max, however one teacher, Jakob, worked very closely with Max and Max's mother to support Max's AT needs. Jakob describes how Max used his existing braille device for all of his communication and how it had created his "social connection", as it was used in emailing, Facebook, writing stories, and all academic learning. The teachers offered Max a slow transition onto the new device, by letting him keep his existing device in some core classes. Yet, as Jakob describes, Max endures difficulties when learning to use the new braille device, a BrailleNote Touch, that cause him to 'lose faith' in the device:

Jakob: *I had a conversation with [Max] about that as to what his issue was with the BrailleNote Touch. And I said I wanted to hear because I want to understand it. Cause I think it's a really good device. You know, it's a whole, their whole life in, not their whole life but [unclear words] and be very independent and carry it about. So what he said is he lost faith in it because there was too many problems. [...] He didn't trust it. [...] He had too many incidents just with it. And he said, he said any new device that comes out, and I had to agree with him, this often has a lot of trouble shooting problems initially. [...] So he did, he lost confidence in it. He said he lost work in it. I think he couldn't cut and paste things. There was, there was a few [...] specific things that happened that caused him to lose faith and he had a lot of faith. So I don't think he was so much resistant. He may not have been resistant to the change, I don't know.*

Jakob adds that the teachers had not yet been trained fully on the new device and could not adequately support Max in his learning process. Then, another teacher, Tom, describes how they tried to support Max to have a better experience with the new device.

Tom: *The young lad had been put off slightly [...] and there was a nervousness around the device. So what we did was we invited a specialist trainer to come in. And what the boy did was he wrote a list of his concerns. [...] We sent that to the trainer so that the trainer had read it in advance. And when he came in he was able to alleviate 99.9% of the concerns.*

As Jakob describes, however, Max's acceptance of the new device was not quite there, and so with the support of his mother Max decided to try a different device, a 'Brailiant'. Jakob describes how this changed the boy's experience dramatically:

Jakob: *Max, who was resistant to the BrailleNote Touch moved over to the Brailiant to the point that his family bought him a Brailiant. And he much prefers that because I can type, because he's got a hearing impairment, if I type on the keyboard it comes up. So I can communicate much faster with him and he's able to do a lot of things with it that, you know, meet his needs. So there is an excitement and a wanting to conquer with him. And he keeps, we keep going into deeper and deeper features now on like, you know, like pressing F12 or alt F4 and how do we do that, like you would do on a normal keyboard, there's shortcuts. So there is a, a real conquer with this pupil because he really wants to master this device because he feels it's very dynamic for him and he can use it. He can take it with him and just connect it into a PC and he can use it in any situation although that PC needs Jaws. So there is that, that is going on for him. Especially when we can communicate and, you know, it's harder to talk to him than it is to type and then read the braille. We could communicate very fast and actually have a lot of exchange [...] So I've found that very useful. [...] The other thing about learning is that, right see the braille note touch and, you know, and the Brailiant. See it's the Humanwear uses certain standard ways of doing things like, you know, space 4 and 6, it's like tab. As long as that sort of format is consistent they can transfer their notes see. So Max, for example, transferred his knowledge from the Apex to the Brailiant and a lot of the commands were similar. [...] I mean Max was doing things in the Brailiant that I didn't know because he had learnt it in the Brailiant.*

Jakob continues to describe how Max changed with the use of the Brailiant, he was happy and his sense of wellbeing was noticeable:

Jakob: *[...] again I'm thinking about Max with, with the Brailiant cause I mean that's quite a focused example but he, you know, there was an obvious, there was a change in his sort of happiness that he could, I felt it made him very happy that he had the ability, it gave him the confidence to do things that, you know, he couldn't previously do. And I think with a lot a' the technology as well being able to go online, it allows him to connect with the rest to the rest a' the world. It's an important way for them to connect. [...] I have noticed that. I mean with, with the more complex need pupils as well, just being able to interact. I mean these kids, a lot a' these kids when they've got more complex needs or more sensory needs, just being able to have feedback and interaction and expression. [...] Communication is so important. It's so important for them and the technology sometimes opens up channels or opens up ways of doing that that I actually think it can often be very important for kids with, either visually impaired kids or kids with complex needs. Technology is actually an important doorway into the rest a' the world. Especially a world where already so many of us are connected through technology. I'm not necessarily agreeing wi' that but it becomes. So there is a sense but I did see that with Max, like a real sense of like smile and happiness that, you know, I really feel I like this.*

Jakob continues to explain how his personal relationship with Max opened up on account of Max's ability to have a technology that opened up Max's world. Jakob explains how Max became more open to him and more trusting of him as his teacher, and the other teachers emphasise this change as well:

Jakob: *And it, and I have to say that improved my personal relationship with this pupil [...] because I introduced this piece of technology to him that made a difference. So therefore he associated, that was a, a nice boon for me, you*

*know, with a pupil that ended up liking me because what I felt that's what happened. That was a, so, you know, he, because he just wanted to feel in charge of things and, and in control. I mean I don't know what else to say.*

Interviewer: *I was gonna say just to follow up on that because you've mentioned that before that you were able to communicate fast with him.*

Jakob: *Yeah that's right. Yes, that's what happened. There was humour, a lot of humour went into that as well. Like we just, we would spend [laughs] sometimes ten minutes winding each other up. And he liked that. I mean he really needed that level of [...]*

Tom: *Cause he's missing that banter.*

Jakob: *[...] he missed, he really needed that, you know. I would just slag him off, 'I beat you at chess again this week [respondent laughs], your chess is rubbish'. And he would say, 'you have more humility, you know [all laugh]. You're not modest. I'm gonna beat you eventually'. And it was just, that was important, there was a connection that happened there that, [...]. So he was very locked into his own world. So this, this piece of technology helped him break out of his world.*

The interview discussion suggests that, for Max, the AT is vital for his cognitive functioning and agency and this extends to his social wellbeing, comfort, and his desire to build relationships and to continue to learn. We could say that there is a significant difference in Max's connection to each of the ATs he used. In the case of the first braille technology (BrailleNote Touch) it appears that the AT remained an external instrument, as with Otto's notebook. In that case, the AT is described in ways that indicate a low level of cognitive integration, a possible non-systems approach and thus a low degree of fluency and confidence, an unrelaxed use of the device. However, the second technology Max learned to use (Brailiant) started to become an extension of himself, rather than merely an external instrument that he employed.

That Max, and his teachers, are apt to treat the cognitive process employing AT (the Brailiant) as part of a systems approach, and as such as a manifestation of his extended cognitive self, is indicated in the way they describe the change in his wellbeing, including his happiness and increased social interaction. From their descriptions, there is a good indication that any cognitive success resulting from the use of this cognitive process would naturally be attributable to Max's cognitive agency rather than to factors that are external to that cognitive agency. In short, this is grounds to think that what we have on display here is not merely a cognitive process that employs AT (i.e., as subject-and-instrument—a non-systems approach), but rather an extended cognitive process (and thus extended cognition) that has AT as a proper part. In our terms, this would be indication of a case of extended cognitive integrator ECI.

Indeed, Jakob noted that Max's mastery of the AT often far-outpassed his own competence with the device, and precisely because of how it was integrated into Max's cognitive processes in a way that isn't paralleled with the teacher's use of the device (which is usually typically instructional):

Jakob: *I mean Max was doing things in the Brailliant that I didn't know because he had learnt it in the Brailliant.*

Max's mastery of AT thus involved a fluent, confident, relaxed employment of it, which in turn indicates a high level of cognition integration.

Importantly, it appeared that the structure of the learning process by which Max learned to integrate the technology mattered. With the BrailleNote Touch, while Max did struggle to use the device, this struggle could be deemed destructive rather than productive. Max's frustration with the device, leading to a loss of trust in it, outweighed the eventual success he had in using it to meet his communication needs. There is indication that Max's struggle using this device never became productive. With the Brailliant, in contrast, although Max also struggled with learning to use it, there is indication that the struggle was productive. Max endured the challenges with learning to use the AT in ways that appeared to incite his reflection and problem-solving. Jakob's description of Max indicates that he was excited to 'debug' the device, and the device itself promoted his interactions with others, like his teachers, who could act as resources for him to continue to learn in a deep way with and through the AT. Applying a systems approach here we see that Max is not to be seen as a passive grateful recipient of the device but rather is the driver of the AT adoption process, in that he himself takes control of the evaluation, use and choice of device, and that leads him to embrace Brailliant in ways that go beyond what was expected from him. Max is seen therefore as an individual, who brings in his own experience, struggles, and effort which may differ in different contexts, such as within school, home or varying leisure pursuits. His own expertise becomes central not only to his own personal needs but also to the broader educational needs of the teachers and further afield.

The case of Max can make us consider what it means to understand AT as part of extended cognition. Terms like 'mastery' and 'seamless use', which are often used to indicate the kind of cognitive integration needed for extended cognition, should not be understood in a naïve way as if the user's use of AT is always smooth and will never pose him or her challenges. Rather, as is suggested in Max's case, to understand the AT as part of his extended cognitive processes means that he may still get confused, feel challenged and *struggle* with the device, but the struggle will be of a sort that inspires his metacognition, critical reflection and problem solving in order to continue to



function as a cognitive agent in his world. In this case, that means for Max to continue to have the desired fluid and free forms of communication. Just as with other cognitive processes, like memory, which as we mentioned before, can fail us at times, so too AT could fail the user, but this does not mean that the AT is not part of the user's extended cognition. What is critical is how the user engages with that 'error message' and whether they engage it as part of their identity. Max's case appears to support our hypothesis that how a learner learns to integrate AT is critical for whether they transition from mere AT use to ECI, and we believe it demonstrates a need for further research.

#### 4. IMPLICATIONS

It has been argued that the particular use of AT in special needs education constitutes an especially compelling example of extended cognition, because of how AT systems enable the learner to integrate the AT within their day-to-day life, such that it is seamlessly and fluently employed (and certainly as seamlessly and fluently employed as corresponding biological cognitive processes). If one grants this claim, then what implications does it have?

One general issue raised by this way of thinking about the use of AT in special needs education concerns how it accords with a theoretically dominant conception of disability. According to the social model of disability, disability is to be understood in terms of a mismatch between the subject's abilities and their environment. Disability on this conception thus involves a relationship between the subject and her surroundings. As a result, and in contrast to the medical model of disability (whereby disability concerns only an internal biological feature of the agent), the mere fact that a person has an impairment doesn't itself entail that she is disabled.<sup>20</sup> This is important, since it places an important obligation on those aiming to assist those who have impaired abilities to make the environment amenable to their impairment, and in so doing remove the barriers to their disability. This also aligns to the AT systems approach that is currently prevalent in the AT literature.<sup>21</sup>

Once we understand certain kinds of AT as extended cognitive processes, however, then this has important implications for how one thinks of this standing 'environmental' obligation, where feasible, to make environmental accommodations that remove the barriers to disability. The notion of an 'environment' in play here was clearly originally meant in its usual sense of the wider physical

and social setting that the person finds themselves in. But in the context of extended cognition, it can also involve possible cognitive augmentations of the person's cognitive capacities (i.e., to offset against cognitive impairments), where these are in the relevant sense 'external' to the person's biological cognitive capacities. The sense in which an extended cognitive process is 'external' to the person is obviously very different from the kind of externality at issue with normal environmental factors, given that, as we have seen, extended cognitive processes are part of the person's cognitive character (such that any cognitive successes that they generate are manifestations of their cognitive agency). There is thus a substantive sense in which an extended cognitive process is also 'internal' to the person.<sup>22</sup>

It follows that our standing obligation on the social conception of disability to appropriately modify, where feasible, the environments of cognitively impaired individuals also extends to enabling them to have extended cognitive processes that offset these cognitive impairments. Indeed, one could plausibly argue that if one has a choice between supporting a cognitively impaired individual to integrate AT as a cognitively extended process (i.e., an AT systems approach) as opposed to only offering that individual a merely technological/environmental response to their cognitive impairment (i.e. a non-AT systems approach), then, *ceteris paribus*, one should opt for the former. In particular, as we have suggested with the case of Max above, it can enhance the user's wellbeing when they are afforded opportunities to access AT that can be used seamlessly and fluidly as part of an extended cognitive process rather than simply as an external resource to be employed merely as an instrument. In short, ECI is to be favoured over mere AT use.

Where AT is offered to special needs learners merely as a technological aid in an educational setting, then it is natural to suppose that the AT is only serving a specific educational need. This has implications for its use, not least that there is no obvious reason why the AT should be made available to students outside of this educational setting, such as back in the home. Matters are very different, however, if we are thinking of the AT *as a component part of the subject's extended cognitive character*. Although the AT is being introduced in a specific educational setting, the kind of cognitive enhancement that is generated is not particular to this setting, but rather concerns the general cognitive character of the subject. To deprive the student of this aspect of their cognitive character outside of the educational context would thus constitute a harm to the subject, and hence should be avoided where possible. This is especially so given that the AT is employed in a developmental setting, as being deprived of the AT for significant periods (e.g., school holidays) could potentially do real harm to the student's cognitive development.

Indeed, understanding a student's AT use as part of their cognitive character, and as supporting their cognitive agency, has implications for educational policy. For one, this view provides a rationale for allowing the AT to be taken home by the student. Moreover, it also means that not just specialist teachers, but all teachers involved with the student's education need to have proper training so as to understand and support the student's learning and use of AT within a systems approach. Additionally, this view gives grounds to the idea that parents and other carers involved in the child's life need to be offered forms of training that improve the child's use of AT outside the school. In all cases of training, including in the training of parents and carers outside the school setting, there must be attention given to the difference between the learner's 'productive' and 'destructive' struggle with the AT, so that ways of supporting productive struggle can be identified and determined in collaboration with the learner, and not independently of them.

Relatedly, thinking of certain kinds of AT use as a form of extended cognition also changes how we conceive of the educational assessment of special needs children in these cases. Insofar as the AT is an extended cognitive process, and thus a component of their cognitive character, then it is hard to see what rationale there would be to assess a student's educational performance independently of the AT. At the very least, one would want to ensure that an adapted assessment is put in place that takes into account the AT capabilities.<sup>23</sup>

These points about the implications of AT use as extended cognition in special needs schools also have potential relevance for how we think about technology use for learners' with disabilities in mainstream schools. Modern education in developed countries is now increasingly conducted in a technologically-embedded fashion. Even so, it is not clear that there is quite the kind of close-knit relationship with technology that we find with special needs students and certain kinds of AT. Accordingly, it would not follow from the fact that, in certain cases, the use of AT in special needs education amounts to extended cognition that extended cognition is also commonly found in mainstream educational settings.

If the conditions of the environment for learners' with disabilities in mainstream settings can fully support learners' AT use (in an AT systems approach), and in particular, if learners' are offered support to engage in productive struggle while learning to use AT, then we would expect the conclusions that we have derived from a consideration of extended cognition in the specific context of schools specialising in special needs education to carry over, *mutatis mutandis*, to mainstream schools. Indeed, one could plausibly contend that special needs education, due to its distinctive reliance on AT, represents a kind of 'educational vanguard' in this regard, in that it offers an insight

into what is needed for the future of supporting learners with disabilities in mainstream education. In particular, thinking about educational technology in mainstream settings along extended cognition lines will yield similar points about the special value of the student's relationship to this technology (e.g., in that it is not merely an instrument), the importance of preserving this relationship in this developmental setting, and how this affects our understanding of the educational assessment of the student.<sup>24</sup>

Our discussion also has implications for what qualifies as a cognitive impairment. The very notion of a cognitive impairment is itself relative to a reference class. There can be learners in mainstream education who may have difficulty with certain kinds of cognitive tasks relative to their peers. Does this not qualify as a cognitive impairment? If so, then shouldn't there be a standing obligation in even a mainstream educational setting, where feasible, to provide technological/environmental solutions, ideally those that could become part of the student's extended cognition? Education is plausibly concerned with the enhancement of cognitive character, after all, so if there are ways of developing cognitive character which are specifically technological, then what reason, beyond mere tradition, is there for not exploiting them?<sup>25</sup> Granting the possibility that technology use in mainstream education could involve cases of extended cognition—in the way we have discussed is occurring in special needs schools—thus has the potential to lead to a very different conception of what such an education might involve, in terms of its development not just of a student's cognitive character, but also more specifically their extended cognitive character.

## 5. CONCLUDING REMARKS

We have argued for a number of claims here. The core thesis has been that we can understand certain kinds of use of AT in special needs education as a form of extended cognition. Indeed, we have seen that such cases might be especially good illustrations of what extended cognition would look like (at least when compared with Otto-style cases), due to the way that the AT is seamlessly integrated into the student's cognitive processes through an AT systems approach. We have also seen that this core thesis has a number of important implications, not only for special needs education, but for how we think of the use of technology in the increasingly technologically-embedded environments now found in non-special needs education.<sup>26</sup>

## REFERENCES

- Adams, F., & Aizawa, K. (2001). 'The Bounds of Cognition', *Philosophical Psychology* 14, 43-64.
- (2008). *The Bounds of Cognition*, Blackwell, Oxford.
- Alper, S., & Raharinarina, R. (2006). 'Assistive Technology for Individuals with Disabilities: A Review and Synthesis of the Literature', *Journal of Special Education Technology* 21, 47-64.
- Baehr, J. (Ed.) (2015). *Intellectual Virtues and Education: Essays in Applied Virtue Epistemology*, London: Routledge.
- Barnes, C. (2019). 'Understanding the Social Model of Disability: Past, Present, and Future', *Routledge Handbook of Disability Studies (2nd Edn.)*, (eds.) N. Watson & S. Vehmas, ch. 2, London: Routledge.
- Breyer, D., & Greco, J. (2008). 'Cognitive Integration and the Ownership of Belief: Response to Bernecker', *Philosophy and Phenomenological Research* 76, 173-84.
- Boaler, J. (2015). *Mathematical Mindsets: Unleashing Students' Potential Through Creative Math, Inspiring Messages and Innovative Teaching*, Hoboken, NJ: Wiley.
- Carter, J. A., Kallestrup, J., Palermos, S. O., & Pritchard, D. H. (2014). 'Varieties of Externalism', *Philosophical Issues* 24, 63-109.
- (eds.), (2018a). *Extended Epistemology*, Oxford: Oxford University Press.
- (eds.), (2018b). *Socially Extended Epistemology*, Oxford: Oxford University Press.
- Carter, J. A., & Pritchard, D. H. (2019). 'The Epistemology of Cognitive Enhancement', *Journal of Medicine & Philosophy* 44, 220-42.
- (2017) 'Epistemic Situationism, Epistemic Dependence, and the Epistemology of Education', *Epistemic Situationism*, (eds.) M. Alfano & A. Fairweather, 168-91, Oxford: Oxford University Press.
- Chemero, T. (2009). *Radical Embodied Cognitive Science*, Cambridge, MA: MIT Press.
- Copley, J., & Ziviani, J. (2004). 'Barriers to the Use of Assistive Technology for Children with Multiple Disabilities', *Occupational Therapy International* 11, 229-43.
- Clark, A., (2008). *Supersizing the Mind: Embodiment, Action, and Cognitive Extension*, Oxford: Oxford University Press.
- (2013). 'Gesture as Thought', *The Hand, an Organ of the Mind: What the Manual Tells the Mental*, (ed.) Z. Radman, 255-68, Cambridge, MA: MIT Press.
- Clark, A., & Chalmers, D. (1998). 'The Extended Mind', *Analysis* 58, 7-19.
- Desmond, D., Layton, N., Bentley, J., Boot, F. H., Borg, J., Dhungana, B. M., Gallagher, P., Gitlow, L., Gowran, R. J., Groce, N., Mavrou, K., Mackeogh, T., McDonald, R., Pettersson, & C., Scherer, M. J. (2018). 'Assistive Technology and People: A Position Paper from the First Global Research, Innovation, and Education on Assistive Technology (GREAT) Summit', *Disability & Rehabilitation: Assistive Technology* 13, 437-44.
- Engle, R. A., Langer-Osuna, J. M., & McKinney de Royston, M. (2014). 'Toward a Model of Influence in Persuasive Discussions: Negotiating Quality, Authority, Privilege, and Access Within a Student-Led Argument', *Journal of the Learning Sciences* 23, 245-68.
- English, A. R. (2013). *Discontinuity in Learning: Dewey, Herbart and Education as Transformation*, Cambridge: Cambridge University Press.
- (2016a). 'Dialogic Teaching and Moral Learning: Self-Critique, Narrativity, Community and 'Blind Spots'', *Journal of Philosophy of Education* 50, 160-76.
- (2016b). 'Humility, Listening and "Teaching in a Strong Sense"', *Logos & Episteme* 7, 529-54.
- Galli, G., Noel, J. P., Canzoneri, E., Blanke, O., & Serino, A. (2015). 'The Wheelchair as a Full-Body Tool Extending the Peripersonal Space', *Frontiers in Psychology* 6, 639.

- Giere, R. (2010). *Scientific Perspectivism*, Chicago IL: University of Chicago Press.
- Goldberg, S. (2012). 'Epistemic Extendedness, Testimony, and the Epistemology of Instrument-Based Belief', *Philosophical Explorations* 15, 181-97.
- Goldman, A. (1979). 'What is Justified Belief?', *Justification and Knowledge*, (ed.) G. Pappas, 1-23. Dordrecht: Reidel.
- (1986). *Epistemology and Cognition*, Cambridge, MA: Harvard University Press.
- Greco, J. (2003). 'Further Thoughts on Agent Reliabilism', *Philosophy and Phenomenological Research* 6, 466-80.
- (2009). *Achieving Knowledge*, Cambridge: Cambridge University Press.
- Heersmink, R., & Knight, S. (2018). 'Distributed Learning: Educating and Assessing Extended Minds', *Philosophical Psychology* 31, 969-90.
- Hiebert, J., & Grouws, D. A. (2007). 'The Effects of Classroom Mathematics Teaching on Students' Learning', *Second Handbook of Research on Mathematics Teaching and Learning: A Project of the National Council of Teachers of Mathematics*, (ed.) F. K. Lester, 371-404, Charlotte, NC: Information Age Publishing.
- Hintz, A., Tyson, K., & English, A. (2018). 'Actualizing the Rights of the Learner: The Role of Pedagogical Listening', *Democracy and Education* 26(2), <https://democracyeducationjournal.org/home/vol26/iss2/8>.
- Huebner, B. (2016). 'Transactive Memory Reconstructed: Rethinking Wegner's Research Program', *Southern Journal of Philosophy* 54, 48-69.
- Hutchins, E. (1995). *Cognition in the Wild*, Cambridge, MA: MIT Press.
- Kallestrup, J., & Pritchard, D. H. (2012). 'Robust Virtue Epistemology and Epistemic Anti-Individualism', *Pacific Philosophical Quarterly* 93, 84-103.
- (2013). 'Robust Virtue Epistemology and Epistemic Dependence', *Knowledge, Virtue and Action*, (eds.) T. Henning & D. Schweikard, ch. 11, London: Routledge.
- (2014). 'Virtue Epistemology and Epistemic Twin Earth', *European Journal of Philosophy* 22, 335-57.
- Khasnabis C, Mirza Z, & MacLachlan M. (2015). 'Opening the GATE to Inclusion for People with Disabilities', *Lancet* 386, 2229-30.
- Kotzee, B. (2018). 'Cyborgs, Knowledge and Credit for Learning', *Extended Epistemology*, (eds.) J. A. Carter, A. Clark, J. Kallestrup, S. O. Palermos, & D. H. Pritchard, 221-38, Oxford: Oxford University Press.
- Lenker, J. A., Harris, F., Taugher, M., Smith, R. O. (2013). 'Consumer Perspectives on Assistive Technology Outcomes', *Disability and Rehabilitation: Assistive Technology* 5, 373-80.
- Lynch, S. D., Hunt, J. H., & Lewis, K. E. (2018). 'Productive Struggle for All: Differentiated Instruction', *Mathematics Teaching in the Middle School* 23, 194-201.
- MacAllister, J. (2012). 'Virtue Epistemology and the Philosophy of Education', *Journal of Philosophy of Education* 46, 251-70.
- Maor, D., Currie, J., & Drewry, R. (2011). 'The Effectiveness of Assistive Technologies for Children with Special Needs: A Review of Research-Based Studies', *European Journal of Special Needs Education* 26, 283-98.
- MacLachlan M. (2018). 'Access to Assistive Technology, Systems Thinking, and Market Shaping: A Response to Durocher *et al*', *Ethics Behavior* 29, 196-200.
- MacLachlan, M., & Scherer, M. J. (2018). 'Systems Thinking for Assistive Technology: A Commentary on the GREAT Summit', *Disability and Rehabilitation: Assistive Technology* 13, 492-96.

- Murdoch, D., English, A. R., Hintz, A., & Tyson, K. (Forthcoming). 'Feeling Heard: Inclusive Education, Transformative Learning and Productive Struggle', *Educational Theory* 5.
- Nam, C. S., Bahn, S., & Lee, R. (2013). 'Acceptance of Assistive Technology by Special Education Teachers: A Structural Equation Model Approach', *International Journal of Human-Computer Interaction* 29, 365-77.
- National Council for Mathematics (NCTM) (2014). *Principles to Actions: Ensuring Mathematical Success for All*, Reston, VA: National Council of Teachers of Mathematics.
- Nisbet, P. (2020). 'Assistive Technologies to Access Print Resources for Students with Visual Impairment: Implications for Accommodations in High-Stakes Assessments', *British Journal of Visual Impairment* 38, 222-247.
- Noë, A. (2004). *Action in Perception*, Cambridge, MA: MIT Press.
- Palermos, S. O. (2014a). 'Knowledge and Cognitive Integration', *Synthese* 191, 1931-51.
- (2014b). 'Loops, Constitution, and Cognitive Extension', *Cognitive Systems Research* 27, 25-41.
- Palermos, S. O., & Pritchard, D. H. (2016). 'The Distribution of Epistemic Agency', *Social Epistemology and Epistemic Agency: De-Centralizing Epistemic Agency*, (ed.) P. Reider, 109-26, Lanham, MD: Rowman & Littlefield.
- Pauw, W. T. J. L., de Nooijer, J. A., & Paas, F. (2014). 'Toward a More Embedded/Extended Perspective on the Cognitive Function of Gestures', *Frontiers in Psychology* 5, 359.
- Pritchard, D. H. (2009a). 'Apt Performance and Epistemic Value', *Philosophical Studies* 143, 407-16.
- (2009b). 'Knowledge, Understanding and Epistemic Value', *Epistemology (Royal Institute of Philosophy Lectures)*, (ed.) A. O'Hear, 19-43, Cambridge: Cambridge University Press.
- (2010). 'Cognitive Ability and the Extended Cognition Thesis', *Synthese* 175, 133-51.
- (2012). 'Anti-Luck Virtue Epistemology', *Journal of Philosophy* 109, 247-79.
- (2013). 'Epistemic Virtue and the Epistemology of Education', *Journal of Philosophy of Education* 47, 236-47.
- (2014a). 'Knowledge and Understanding', *Virtue Scientia: Bridges Between Virtue Epistemology and Philosophy of Science*, (ed.) A. Fairweather, 315-28, Dordrecht, Holland: Springer.
- (2014b). 'Virtue Epistemology, Extended Cognition, and the Epistemology of Education', *Universitas: Monthly Review of Philosophy and Culture* 478 (2014), 47-66.
- (2016a). 'Epistemic Dependence', *Philosophical Perspectives* 30, 1-20.
- (2016b). 'Intellectual Virtue, Extended Cognition, and the Epistemology of Education', *Intellectual Virtues and Education: Essays in Applied Virtue Epistemology*, (ed.) J. Baehr, 113-27, London: Routledge.
- (2018a). 'Extended Virtue Epistemology', *Inquiry* 61, 632-47.
- (2018b). 'Neuromedia and the Epistemology of Education', *Metaphilosophy* 49, 328-49.
- (2019a). 'Extended Knowledge', *Extended Epistemology*, (eds.) J. A. Carter, A. Clark, J. Kallestrup, S. O. Palermos & D. H. Pritchard, 90-104, Oxford: Oxford University Press.
- (2019b). 'Philosophy in Prisons: Intellectual Virtue and the Community of Philosophical Inquiry', *Teaching Philosophy* [Online First, DOI: [10.5840/teachphil201985108](https://doi.org/10.5840/teachphil201985108)].
- (Forthcoming). 'Extended Social Epistemology', *Oxford Handbook of Social Epistemology*, (eds.) J. Lackey & A. McGlynn, Oxford: Oxford University Press.
- Pritchard, D. H., Millar, A., & Haddock, A. (2010). *The Nature and Value of Knowledge: Three Investigations*, Oxford: Oxford University Press.
- Rowlands, M. (2009). *The Body in Mind*, New York: Cambridge University Press.
- Rupert, R. D. (2004). 'Challenges to the Hypothesis of Extended Cognition', *Journal of Philosophy* 101, 389-428.
- (2009). *Cognitive Systems and the Extended Mind*, Oxford: Oxford University Press.

- Scandola, M., Aglioti, S., Arcangeli, C. A., Avesani, R., Silvio, I., & Valentina, M. (2019). 'Visuomotor and Interoceptive Influences on Peripersonal Space Representation Following Spinal Cord Injury', *PsyArXiv*, DOI:10.31234/osf.io/6he27.
- Scherer, M. J. (1991). 'Assistive Technology Use, Avoidance and Abandonment: What we Know So Far', *Proceedings of the Sixth Annual Conference, Technology and Persons with Disabilities*, (ed.) H. Murphy, 815-26, Los Angeles, CA: Office of Disabled Student Services, California State University, Northridge.
- (ed.). (2002). *Assistive Technology: Matching Device and Consumer for Successful Rehabilitation*, Washington, DC: APA Books.
- Scherer, M. J., & Sax, C. (2010). 'Measures of Assistive Technology Predisposition and Use', *Rehabilitation and Health Assessment: Applying ICF Guidelines*, (eds.) E. Mpofu & T. Oakland, 229-254, New York: Springer.
- Shakespeare, T. (2013). 'The Social Model of Disability', *The Disability Reader* (4<sup>th</sup> Edn.), (ed.) L. J. Davis, 214-21, London: Routledge.
- Shapiro, L. (2011). *Embodied Cognition*, New York: Routledge.
- Siegel, H. (2017). *Education's Epistemology: Rationality, Diversity, and Critical Thinking*, Oxford: Oxford University Press.
- Smith, E., Gowran, R., Mannan, H., Donnelly, B., Alvarez, L., Bell, D., Contepomi, S., Ennion, L., Hoogerwerf, E.-J., Howe, T., Jan, Y.-K., Kagwiza, J., Layton, N., Ledgerd, R., MacLachlan, M., Oggero, G., Pettersson, C., Pousada, T., Scheffler, E., & Wu, S. (2018). 'Enabling Appropriate Skills-Mix Towards Progressive Realisation of Equitable Access to Assistive Technology', *Disability & Rehabilitation: Assistive Technology* 13, 445-53.
- Sprevak, M. (2009). 'Extended Cognition and Functionalism', *Journal of Philosophy* 106, 503-27.
- (2019). 'Extended Cognition', *Routledge Encyclopedia of Philosophy Online*, (ed.) T. Crane, Routledge: London.
- Townsend, C., Slavit, D., & McDuffie, A. R. (2018). 'Supporting All Learners in Productive Struggle', *Mathematics Teaching in the Middle School* 23, 216-24.
- Warshauer, H. K. (2014). 'Productive Struggle in Middle School Mathematics Classrooms', *Journal of Mathematics Teacher Education* 18, 375-400.
- Wheeler M. (2013). 'Is Cognition Embedded or Extended? The Case of Gestures', *The Hand, an Organ of the Mind: What the Manual Tells the Mental*, (ed.) Z. Radman, 269-301, Cambridge, MA: MIT Press.
- Wokke, M. E., van Gaal, S., Scholte, H. S., Ridderinkhof, K. R., & Lamme, V. A. (2011). 'The Flexible Nature of Unconscious Cognition', *PLoS One* 6, 25729.



## NOTES

<sup>1</sup> Some of the theoretical literature on AT uses the terminology *adaptive technology* to pick out a particular kind of AT that is specifically designed to help overcome an impairment. One also finds conceptions of AT in the literature that are very broad indeed. For example, following the guidance found in the US Individuals with Disability Act (IDEA), in some educational quarters AT is understood such that:

“It includes not only the technological devices or software that assists the learner with disability, but also the raft of services and professionals, teachers and family members who support the student to ensure greater outcomes.” (Maor *et al* 2011)

The problem with such a broad characterization for our purposes is that it is so general that it could apply to almost anything relevant to a student’s educational development. In any case, our interest is in the specific devices that are employed to assist individuals with impairments.

<sup>2</sup> For a recent survey of a range of contemporary empirical research studies on AT in special needs education, see Maor *et al* (2011). See also Alper & Raharinirina (2006).

<sup>3</sup> Expressed a bit more carefully still, we could think of the extended mind thesis as being specifically concerned with the *vehicle* of mental content (which on this view can include environmental factors). For a very useful recent overview of the extended mind/cognition theses, and how best to understand them, see Sprevak (2019).

<sup>4</sup> See Giere (2010) and Goldberg (2012) for discussion of why one might accept the extended cognition thesis while rejecting the extended mind thesis.

<sup>5</sup> Interestingly, in Clark & Chalmers (1998) the extended cognition thesis is effectively taken as obvious; it is the extended mind thesis that is held to be in need of an argument. The idea that the extended cognition thesis is uncontentious would come as a surprise to most contemporary epistemologists—as explained in Pritchard (2016a), contemporary epistemology has tended to instead assume a kind of *epistemic individualism* which is incompatible with extended cognition.

<sup>6</sup> As such, we will not be defending the extended cognition thesis for our purposes, but rather taking it as a live research programme that can be applied to AT. For some of the key recent literature that critiques extended cognition, see Adams & Aizawa (2001; 2008), Rupert (2004; 2009), and Sprevak (2009).

<sup>7</sup> See, for example, Palermos (2014a; 2014b) and Pritchard (2018a; 2019a).

<sup>8</sup> See, for example, the virtue reliabilist account of cognitive integration offered by Greco’s (2003; 2009, ch. 9; cf. Breyer & Greco 2008).

<sup>9</sup> For an account of extended knowledge, see Pritchard (2010; 2018a; 2019a). See also Carter *et al* (2014), and the recent volume of contemporary work on extended epistemology edited by Carter *et al* (2018a).

<sup>10</sup> For more on this point that the explanatory relationship between cognitive success and cognitive agency on the virtue-theoretic account needs to be relatively modest, see the critical discussion of the relative merits of ‘robust’ (or ‘strong’) virtue epistemology *versus* ‘modest’ (or ‘weak’) virtue epistemology in Pritchard (2009a; 2009b; 2012a; 2016a), Pritchard, Millar & Haddock (2010, chs. 2-4), and Kallestrup & Pritchard (2011; 2012; 2013).

<sup>11</sup> See also the recent account of cognitive integration in terms of dynamical systems theory that is offered by Palermos (2014a; 2014b).

<sup>12</sup> See, for example, Clark (2013), Wheeler (2013), and Pauw *et al* (2014).

<sup>13</sup> This kind of case in fact functions best as an illustration of a particular kind of extended cognition (/extended mind) which emphasises the embodied nature of mental and cognitive agency—*viz.*, *embodied cognition*. For some recent discussion of this thesis, see Noë (2004), Chemero (2009), Rowlands (2009), and Shapiro (2011). In terms of the neuropsychology literature on AT, one plausible example of such embedded cognition concern cases when subjects are appropriately coupled to their wheelchairs (e.g., through continued use of a specially adapted wheelchair). Researchers have noted that this can result in the subject having an extended peripersonal space when compared to non-wheelchair users. Appropriate integration of the (non-information-processing) AT therefore literally changes the way that the user experiences the world as compared to other (non-extended) technology users, in such a way to change their embodied cognition of the world around them. For further discussion, see Galli *et al* (2015) and Scandola *et al* (2019).

<sup>14</sup> Note too that since our focus is on AT (i.e., and thus on *technology*), we are also here setting aside a distinctive kind of socially extended cognition that involves information-processing, known as *distributed cognition*. While this can be centrally relevant to cases of cognitive impairment, albeit one that involves a cognitive extension across subjects rather than between individual subjects and technology, it would take us too far away from our current concerns to be discussed here. For one of the seminal works on distributed cognition, see Hutchins (1995). For specific discussion of the epistemological ramifications of distributed cognition, see Palermos & Pritchard (2016) and Carter *et al* (2018b). For one prominent example of how distributed cognition can be relevant to cognitive impairment (such as afflicts Otto, for example), see the literature on how transactive memory systems—found, for instance, in elderly couples who exhibit

declining memory when evaluated individually, but who can successfully perform memorial tasks when working together—seem to exemplify distributed cognition. For recent philosophical discussion of this issue, see Huebner (2016) and Pritchard (*forthcoming*).

<sup>15</sup> See, for example, Wokke *et al* (2011).

<sup>16</sup> These are points that are made in numerous studies of AT. See, for example, Scherer (1991), Lenker *et al* (2013), and Nam *et al* (2013).

<sup>17</sup> For a study that focusses on barriers to the educational uptake of AT of this kind, see Copley & Ziviani (2004).

<sup>18</sup> See, for example, the papers collected in Scherer (2002).

<sup>19</sup> Research shows that *productively struggling* occurs when learners are wrestling with the new learning material in ways that challenge them to critically and reflectively inquire into the limitations in their own established knowledge and ability, so as to expand such knowledge and ability. On this concept of productive struggle in learning and how teachers can support it, see English (2013; 2016a; 2016b), Hiebert & Grouws (2007), Warshauer (2014), Boaler (2015), and Hintz *et al* (2018). On the corresponding notion of *destructive struggle*, see English (2013). In recent years, a significant body of research, in particular in mathematics education, has highlighted that supporting learners' to productively struggle is an equity issue, and that educators need to give all learners access to opportunities to struggle productively during learning, including students with disabilities. See Lynch *et al* (2018), Townsend *et al* (2018), and Murdoch *et al* (*forthcoming*). Notably, mathematics education in the United States has embedded the idea of supporting 'productive struggle' into policy on effective teaching—see NCTM (2014).

<sup>20</sup> For two useful recent discussions of the social conception of disability, see Shakespeare (2013) and Barnes (2019).

<sup>21</sup> See Desmond *et al* (2018), MacLachlan (2018), and Smith *et al* (2018).

<sup>22</sup> For more on this point in the specific context of the epistemology of cognitive enhancement, see Carter & Pritchard (2019).

<sup>23</sup> In this regard, see also Nisbet (2020).

<sup>24</sup> For further discussion of how to situate extended cognitive processes within educational contexts in light of a virtue-theoretic understanding of the epistemic goals of education, see Pritchard (2014b; 2016b; 2018b), Carter & Pritchard (2017), Heersmink & Knight (2018), and Kotzee (2018). For an articulation and defence of a virtue-theoretic account of the epistemic goals of education, see Pritchard (2013).

<sup>25</sup> For further discussion of the epistemic goals of education, see MacAllister (2012), Pritchard (2013), and Siegel (2017). See also the papers collected in Baehr (2015).

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